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UNITED STATES PATENT APPLICATION

FOR

METHOD AND APPARATUS FOR MAINTAINING CONSISTENT DATA

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Method and Apparatus for Maintaining Consistent Data

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The invention relates to the field of communications. More specifically, the invention relates to communication networks.

Background of the Invention

[0002] Control card redundancy improves reliability of network elements. Having a secondary control card with the same information as the primary control cards enables a network element to withstand hardware and/or software failure on the primary card. In addition, the secondary control card enables maintenance of network elements. The primary control card can be pulled for repairs or testing because the secondary control card will take over operations.

[0003] To avoid interruptions in service, consistency must be maintained between control cards. Information received by the primary control card is passed to the secondary control card. After the information is stored on the primary control card it is copied to the secondary control card.

[0004] This prior art technique has the disadvantage of exposing the network element to disruption. A failure may occur before information is copied to the secondary control card. When the secondary control card takes over operation of the network element, the secondary control card will be lacking information. The network administrator will have to discover the inconsistencies and correct these inconsistencies. In addition, the inconsistencies may cause service to be disrupted to a customer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The invention may best be understood by referring to the following description and accompanying drawings that are used to illustrate embodiments of the invention. In the drawings:

[0006] Figure 1 is a diagram of a network element according to one embodiment of the invention.

[0007] Figure 2 is a diagram of the memory 109 and the memory 107 of Figure 1 according to one embodiment of the invention.

[0008] Figure 3 is a diagram of a configuration manager interacting with the memory 107 and 109 of Figure 1 according to one embodiment of the invention.

[0009] Figure 4 is a flowchart for storing information to backup memory according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0010] In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the invention.

[0011] Figure 1 is a diagram of a network element according to one embodiment of the invention. In Figure 1, a network element 102 includes two control cards 103 and 105 and an interface 101. Examples of a network element include routers, switches, bridges, edge devices, etc. The control card 103 is connected to the control card 105. The control card 103 includes a processor 113 and a memory 109. The control card

105 also includes a processor 111 and a memory 107. During operation of the network element 102, one of the control cards 103, 105 is designated as the primary control card while the other is the secondary control card. If the primary control card fails then the secondary control card operates in place of the primary control card. Both of the control cards 103, 105 are connected to an interface 101.

[0012] The interface receives input from a user. Although the interface is shown as part of the network element, the interface can be a remote terminal in another embodiment of the invention. This input is sent from the interface to the primary control card. If the control card 103 is the primary control card, then the interface 101 transmits configurations, data, etc. to the control card 103. To maintain consistency between the control cards, information stored on the primary control card is duplicated on the secondary control card. Continuing the example of the control card 103 as the primary control card, the control card 103 transmits information received from the interface 101 to the control card 105 before storing the information in its memory 109. The control card 105 receives information (configurations, network data, etc.) from the control card 103 and writes the information to its memory 107. Before information is written to the memory 107, the information is written to the memory 109.

[0013] In one embodiment of the invention, global mapping is implemented in the network element 102. Global mapping provides a unique address for hardware throughout the network element. With global mapping, the control card 103 can modify the memory 109 directly. Likewise, the control card 105 can modify the memory 107 directly.

[0014] Figure 2 is a diagram of the memory 109 and the memory 107 of Figure 1 according to one embodiment of the invention. In Figure 2, a dashed line 205 indicates a region 201 of the memory 107 being mapped to a region 203 of the memory 109.

The memory management process will associate addresses of the region 201 to addresses of the region 203. In another embodiment of the invention, all of the memory 107 is mapped to the memory 109.

[0015] Figure 3 is a diagram of a configuration manager interacting with the memory 107 and 109 of Figure 1 according to one embodiment of the invention. In Figure 3, a configuration manager 301 receives configurations and processes the configurations. The configuration manager breaks down a configuration into a component or components and determines if a write, update or delete operation or operations is required. The configuration manager 301 then requests a write for write and update operations and a delete for delete operations. The request from the configuration manager 301 corresponds to an address in the memory 109, assuming the memory 109 is being used by the primary control card. Before the request is carried out or executed, an exception causes the operation to be performed on a corresponding address in the memory 107 as indicated by the dashed line 303.

[0016] Figure 4 is a flowchart for maintaining consistency of data between local and remote memory according to one embodiment of the invention. In Figure 4 at block 401, remote memory is mapped. It is assumed that local memory is on the primary control card and remote memory is on the secondary control card. At block 402, local memory is marked with a flag that will cause an exception. In another embodiment of the invention, local memory has read-only permission until a command is successfully performed on remote memory. In such an embodiment, once local memory is modified, read-only permission is reinstated. At block 403, configuration(s) are received from the interface 101 of Figure 1. At block 405, the configuration manager 301 of Figure 3 processes the configurations. At block 407, the configuration manager 301 submits modification requests (i.e., write or delete operations) corresponding to the

processed configurations. At block 409, the submitted modification request(s) for local memory trigger an exception(s). In an embodiment of the invention, this exception is spawned by the operating system when attempts are made to modify given areas of local memory. In one such embodiment, given locations of local memory are associated with given exceptions. For example, referring to Figure 2, a write command is generated for the area 203 of the local memory 109. The exception spawned by the request to write to the area 203 is associated to the area 201 of the remote memory 107. In another embodiment of the invention, a write or delete is only allowed on local memory once remote memory is modified. Otherwise, read-only permission is enforced on local memory.

[0017] At block 411, the exception(s) modifies the remote memory in accordance with the requests (i.e., data is written or removed from the remote memory). At block 413, it is determined if the exception request was executed successfully. If the exception request was executed successfully, then at block 415 the request is executed on the local memory. If the exception request was not executed successfully on the remote memory, then at block 417 an error is generated. The error can be transmitted to an error parser or directly to the user via the interface.

[0018] In one embodiment of the invention, the exception are software interrupts. In another embodiment of the invention, these exceptions are hardware interrupts.

[0019] Insuring data is written or deleted from a secondary memory of a secondary control card before being written or deleted from a primary memory of a primary control card avoids inconsistency of data between control cards. If an error occurs with the control card before the data is written to the primary memory, then the secondary control card has the most recent version of data or configurations. If the data is not

written to the secondary memory, then the primary and secondary control cards still have the same information.

[0020] Furthermore, implementing the embodiments herein of the invention at the lowest level, such as with kernel exceptions, provides a simple backup mechanism with high performance. The complications of higher level backup applications are avoided. In addition, the secondary control card can take control immediately.

[0021] The network element 102 includes line cards in addition to the control cards 103 and 105. Line cards in the network element 102 and the control cards 103 and 105 include memories, processors, and/or Application Specific Integrated Circuit ("ASICs"). Such memories and the memories 107 and 109 include a machine-readable medium on which is stored a set of instructions (i.e., software) embodying any one, or all, of the methodologies described herein. Software can reside, completely or at least partially, within this memory and/or within the processor and/or ASICs. For the purpose of this specification, the term "machine-readable medium" shall be taken to include any mechanism that provides (i.e., stores and/or transmits) information in a form readable by a machine (e.g., a computer). For example, a machine-readable medium includes read only memory ("ROM"), random access memory ("RAM"), magnetic disk storage media, optical storage media, flash memory devices, electrical, optical, acoustical, or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.), etc.

[0022] While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The method and apparatus of the invention can be practiced with modification and alteration within the spirit and scope of the appended claims.

The description is thus to be regarded as illustrative instead of limiting on the invention.